



AMD Overview

July 21, 2005

Roger Wheatly
Business Development Executive

A leading global supplier of innovative semiconductor solutions for the personal and enterprise computing, communications and consumer electronic markets



Founded: 1969

Headquarters: Sunnyvale, California

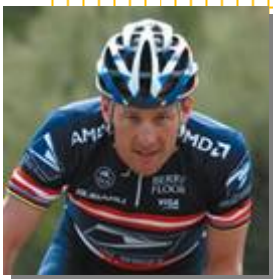
Employees: 15,000 worldwide

Sales Mix: 80% international

2003 Revenue: \$3.5 billion

2004 Revenue: \$5.0 billion

- 43% growth (year over year)



"Suddenly, It's AMD Inside"



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"The Company's striking success raises the possibility of a profound shift in the technology industry."

"...first to market by more than a year with a new class of microprocessors that's popular with corporate clients."

"It has smoothly launched new manufacturing techniques..."

"...and left Intel scrambling to catch up."

Sun and AMD Form Strategic Alliance



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Sun to Offer New Family of AMD Opteron™ Processor-based Systems with Optimized Solaris™, Linux and Java™ Platforms

LAS VEGAS -- November 17, 2003 --Sun Microsystems, Inc. (Nasdaq: SUNW) and AMD (NYSE: AMD) today announced a strategic alliance through which Sun will deliver new AMD Opteron™ processor-based Sun Fire™ systems and optimized versions of the Solaris™ Operating System (OS) and the Java™ platform as well as Linux OS.

The strategic alliance between the two companies will include:

A full range of AMD Opteron processor-based Sun Fire systems from Sun: Throughout the course of 2004, Sun will introduce new AMD Opteron processor powered systems. The current roadmap calls for two and four-way servers to be rolled-out within the next calendar year.

Solaris OS and Sun's Java Enterprise System optimization for the AMD Opteron processor: Currently customers can run Solaris software on AMD Opteron in 32-bit mode. Sun plans to make 64-bit Solaris available on the AMD Opteron processor in the first half of 2004.

Future AMD Opteron Processor-based Designs: Sun and AMD will collaborate on a portfolio of future AMD Opteron processor-based systems and scalability beyond 4-way AMD Opteron processor systems. The parties will also collaborate on coherent HyperTransport™ technology implementations.

Joint ISV Development Program: Sun and AMD will jointly form an iForce™ Partner Program for ISVs and developers creating and porting applications to the Solaris OS.

Joint Customer Centric Marketing Programs: Sun and AMD will collaborate on worldwide marketing activities including a customer seed unit program; joint sales activities; as well as joint product, ISV, developer and channel marketing programs.

➤ ***Outstanding Performance***

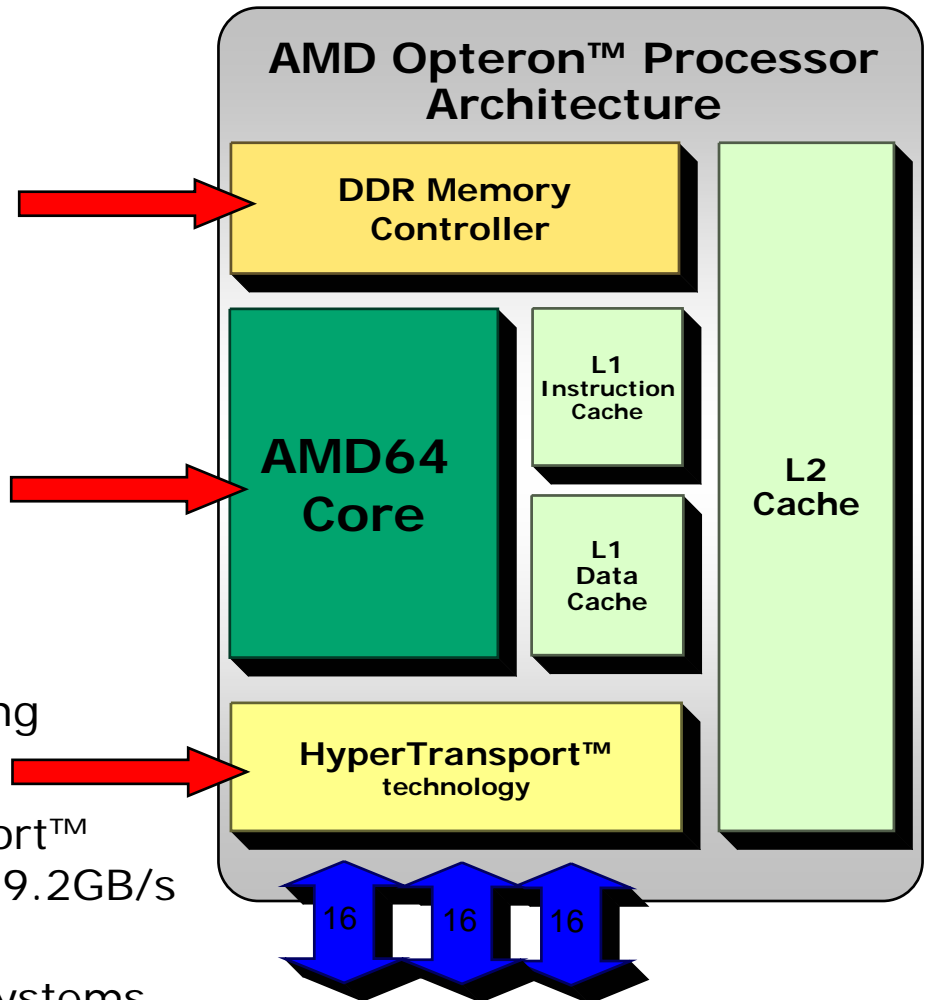
- ✓ High-bandwidth integrated memory controller scales with processor frequency and number of processors

➤ ***64-bit Architecture with 32-bit Compatibility***

- ✓ Approximately 10,000 legacy applications at time of launch

➤ ***Exceptional Scalability***

- ✓ Glueless multiprocessor scaling
- ✓ Removes I/O bottlenecks
 - Three 16-bit HyperTransport™ technology links provides 19.2GB/s peak aggregate bandwidth
- ✓ Reduced costs for high-end systems



AMD64 Processor Core

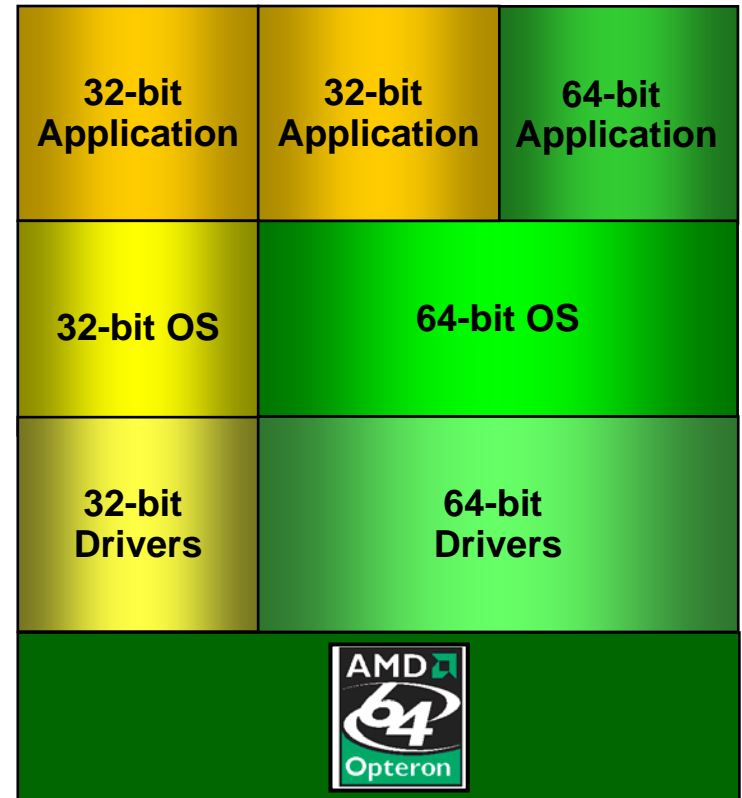
64-bit Processor Core / 32-bit Compatibility



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Practical approach to introducing new software capabilities

- Only two new instructions were added to extend x86 instruction set to support 64-bit addressing
- Runs 32-bit x86 applications without decreasing performance
- 64-bit memory addressing easily handles TB sized databases, thousands of concurrent transactions, and complex graphic models
- 64-bit applications are developed using familiar techniques and tools
- Runs Linux, Solaris, and Windows operating systems



➤ ***Outstanding Performance***

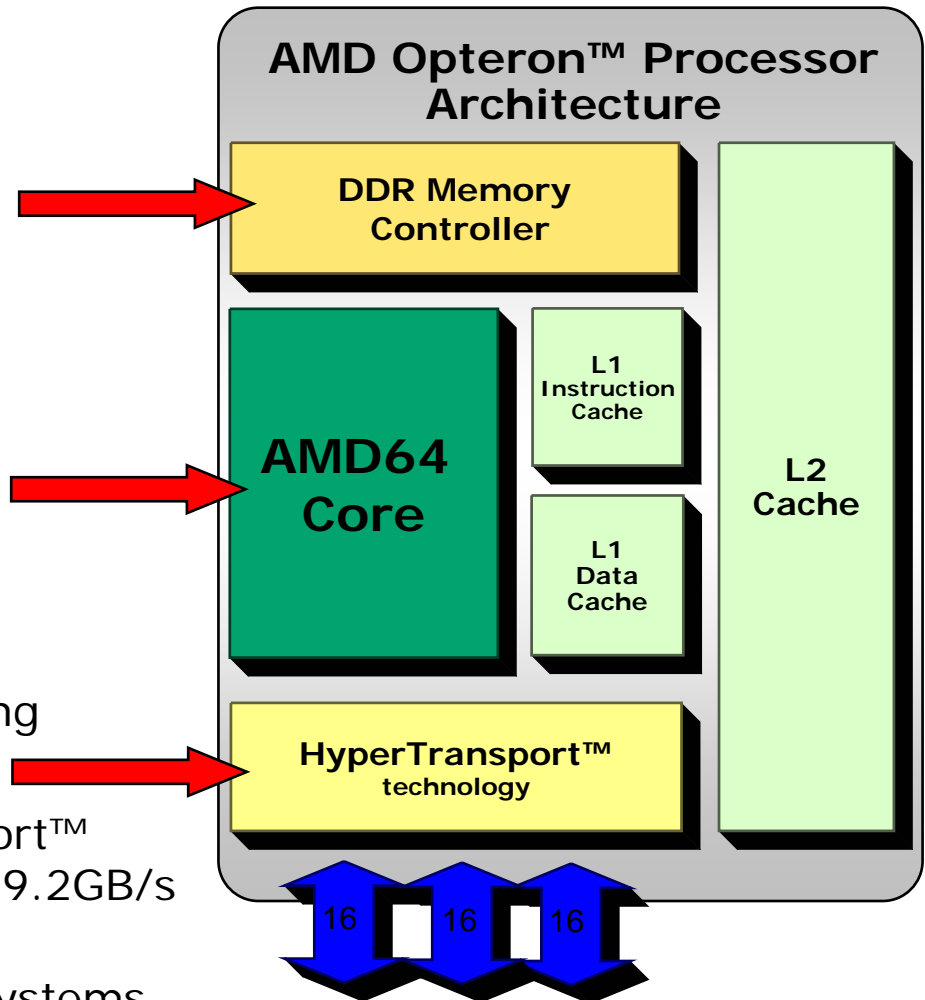
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➤ ***64-bit Architecture with 32-bit Compatibility***

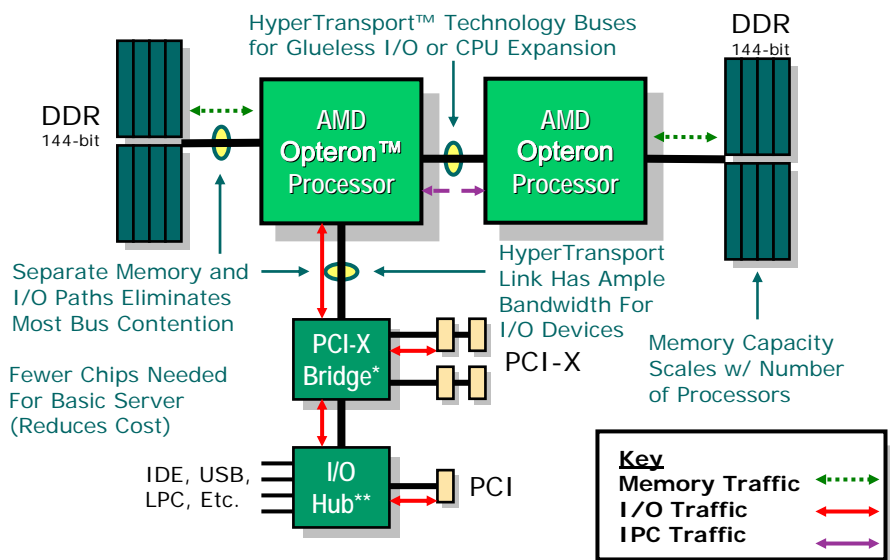
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➤ ***Exceptional Scalability***

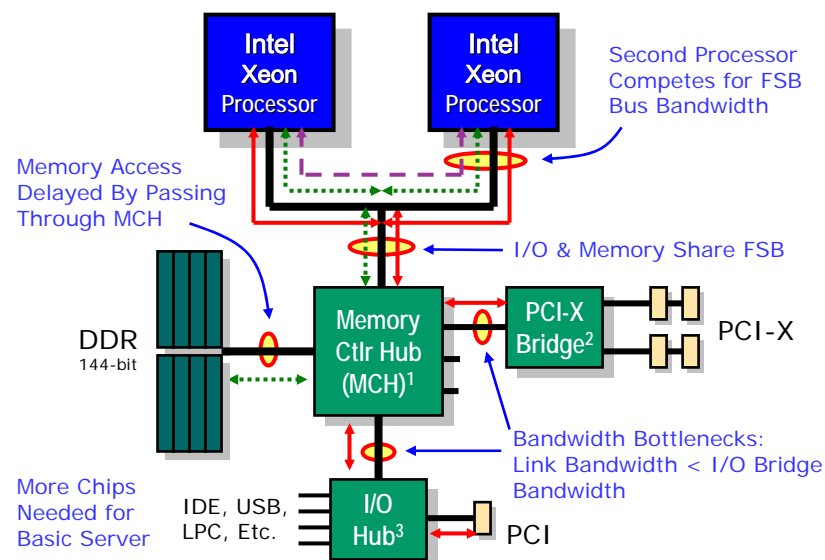
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AMD Opteron™ Processor-based Server



Intel Xeon Processor-based Server



	AMD Opteron™ Processor-based Server	Intel Xeon Processor-based Server
Architecture	AMD64 Architecture <ul style="list-style-type: none"> Enables simultaneous high-performance 32- and 64-bit computing Allows businesses to migrate to 64-bit computing as they require 	IA32 Architecture <ul style="list-style-type: none"> High-performance 32-bit computing only Businesses needing 64-bit benefits must switch to a new architecture
Memory Access Technology	Integrated DDR Memory Controller <ul style="list-style-type: none"> Dramatically reduces latency for fast memory reads Provides a dedicated path from memory to processor Memory bandwidth scales as processors are added Helps eliminate need for larger caches 	<ul style="list-style-type: none"> “Northbridge”-style Memory Controller via Front Side Bus Passage through memory controller hub delays memory reads Processors compete for FSB bandwidth Memory and I/O must share FSB bandwidth, further reducing the efficiency of the FSB
Primary Bus Technology	HyperTransport™ Technology <ul style="list-style-type: none"> At up to 8.0 GB/s bandwidth per link, HyperTransport provides sufficient bandwidth for supporting new and existing interconnects including Fibre Channel, Gigabit Ethernet, PCI-X, PCI-X 2.0, Serial-ATA, Serial Attached SCSI and 10G Ethernet 	Proprietary Hub I/O Buses <ul style="list-style-type: none"> PCI-X bridge's² hub interface has only half the peak bandwidth of the two PCI-X bridges I/O Hub³ interface bus can be overloaded by the aggregate demands of its many I/O devices

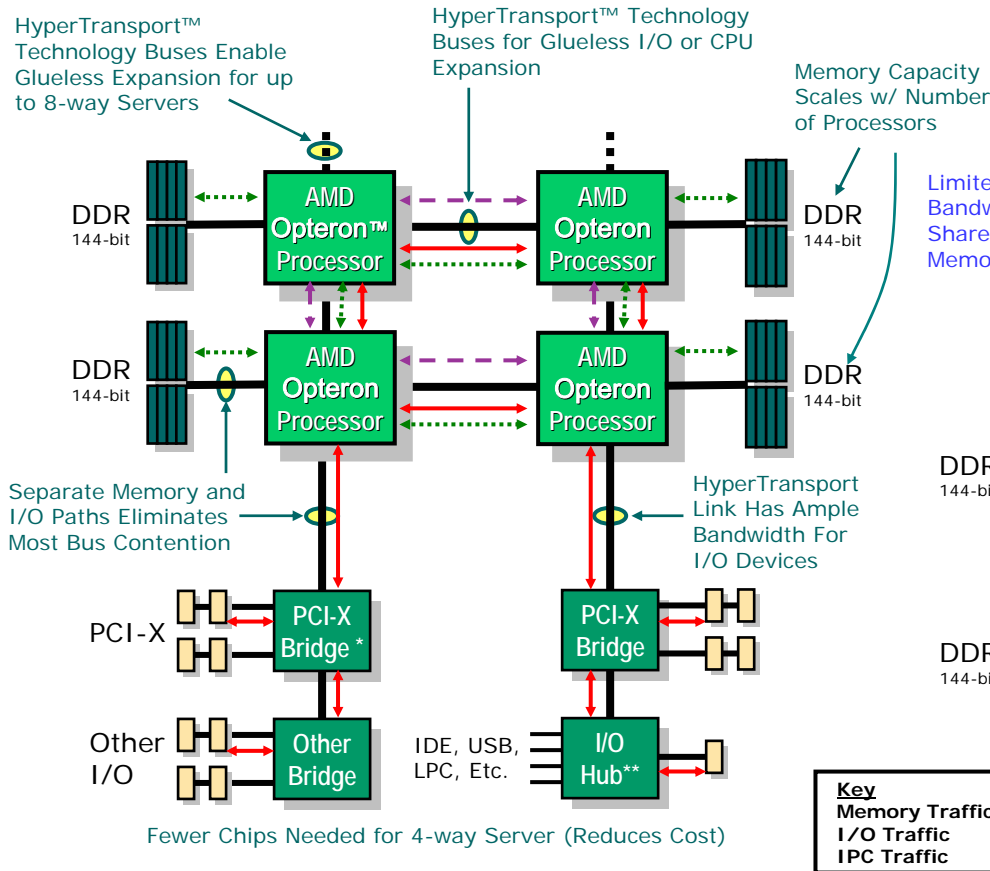
*AMD-8131™ HyperTransport PCI-X Tunnel **AMD-8111™ HyperTransport I/O Hub

¹ Intel E7500 Chipset Memory Controller Hub (MCH) ² Intel 82870P2 64-bit PCI/PCI-X Controller Hub 2 (P64H2)

³ Intel 82801CA I/O Controller Hub 3-S (ICH3-S)

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AMD Opteron™ Processor-based Server

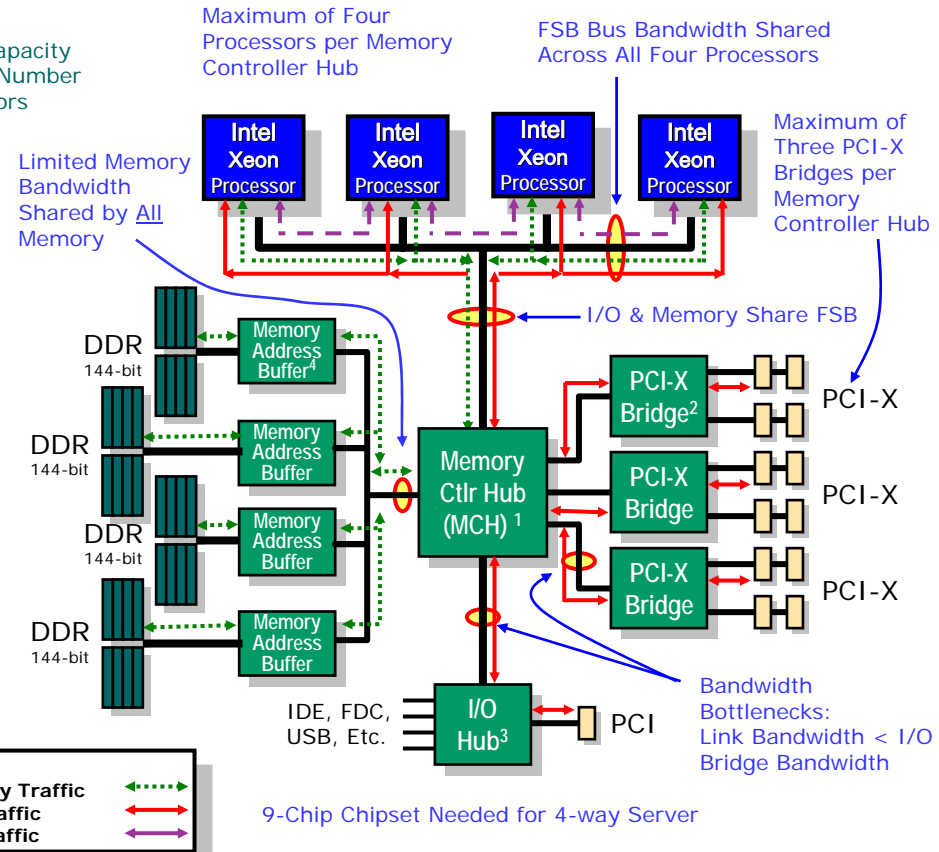


AMD Opteron Processor-based Server

- **AMD64 Architecture:** provides simultaneous high-performance 32-bit and 64-bit computing. Scales to 8P without glue logic.
- **Integrated Memory Controller:** provides low-latency memory access and bandwidth that scales as processors are added.
- **HyperTransport Technology:** at up to 8.0GB/s bandwidth per link, designed to provide a high-speed connection between processors and core logic with sufficient bandwidth for supporting new and existing interconnects.

*AMD-8131™ HyperTransport PCI-X Tunnel **AMD-8111™ HyperTransport I/O Hub

Intel Xeon MP Processor-based Server



Intel Xeon MP Processor-based Server

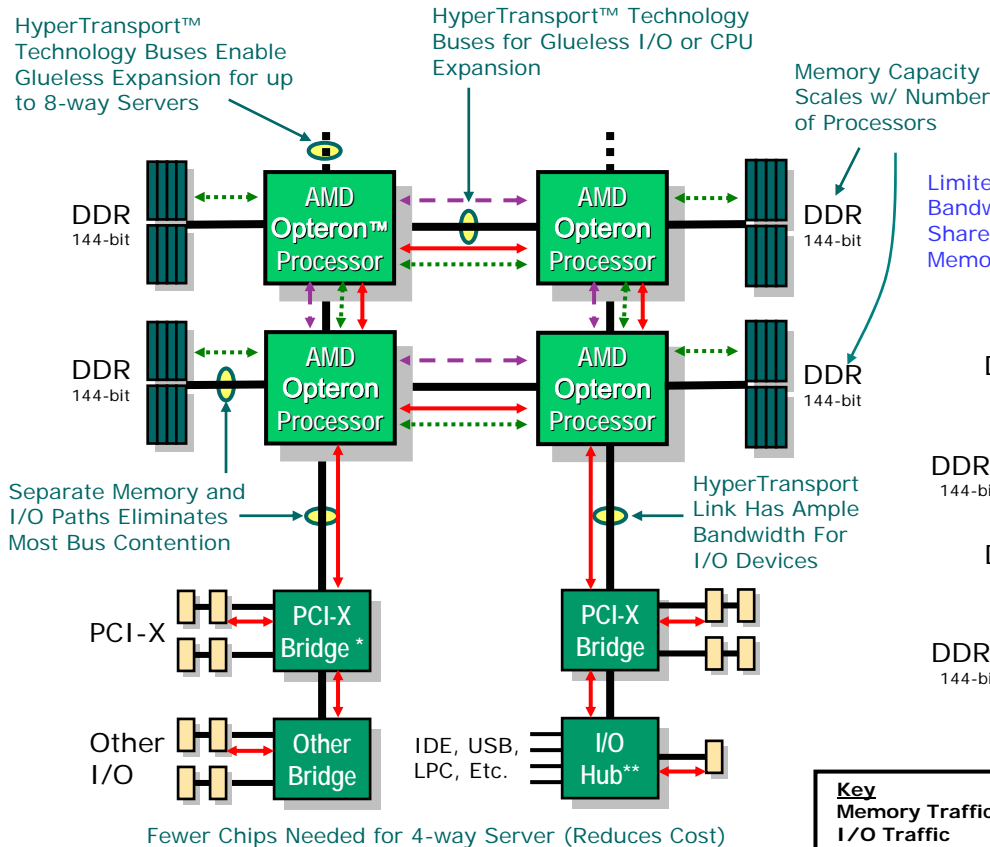
- **IA32 Architecture:** provides high-performance 32-bit computing only—does not offer 64-bit benefits.
- **“Northbridge”-based Memory Controller:** All four processors compete for fixed memory and front-side bus bandwidths—8P solutions require even more chips.
- **Proprietary Hub I/O Buses:** bridge and hub devices can be overwhelmed by the I/O demands of attached peripherals.

¹ ServerWorks CMIC HE Memory Controller Hub (MCH) ² ServerWorks CIOB-X 64-bit PCI/PCI-X Controller Hub

³ ServerWorks CSB5 I/O Controller Hub

⁴ ServerWorks REMC Memory Address Buffer

AMD Opteron™ Processor-based Server

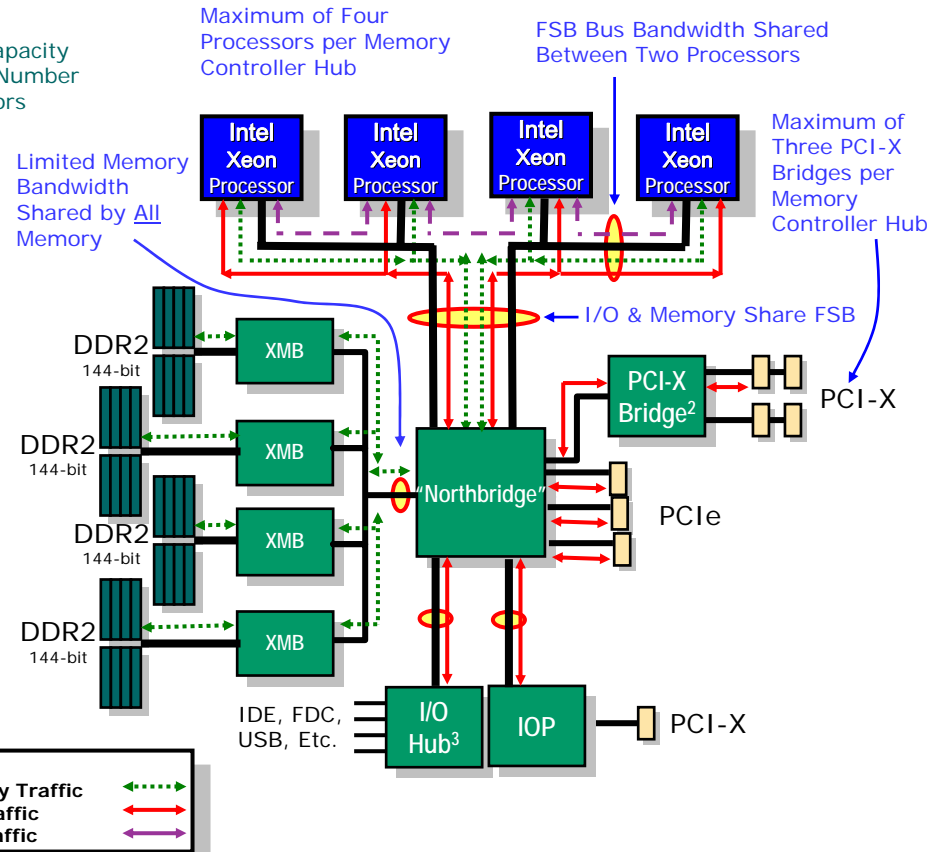


AMD Opteron Processor-based Server

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*AMD-8131™ HyperTransport PCI-X Tunnel **AMD-8111™ HyperTransport I/O Hub

Intel Xeon MP EM64T Processor-based Server



Intel Xeon MP Processor-based Server

- **EM64T Architecture:** allows simultaneous 32- and 64-bit computing
- **“Northbridge”-based Memory Controller:** All four processors compete for fixed memory and front-side bus bandwidths—8P solutions require even more chips.
- **Proprietary Hub I/O Buses:** bridge and hub devices can be overwhelmed by the I/O demands of attached peripherals.

¹ ServerWorks CMIC HE Memory Controller Hub (MCH) ² ServerWorks CIOB-X 64-bit PCI/PCI-X Controller Hub

³ ServerWorks CSB5 I/O Controller Hub

⁴ ServerWorks REMC Memory Address Buffer

Processor Comparisons



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Server System Comparisons	AMD Opteron™	Intel Xeon (Nocona/Irwindale)	Intel Xeon MP	Intel Xeon MP (Cranford/Potomac)
Modular, glueless scalability	Up to 8-way	Up to 2-way	Up to 4-way	Up to 4-way
High performance 32-bit and 64-bit computing	Yes (AMD64)	Yes (EM64T)	No	Yes (EM64T)
Direct Connect Architecture	Yes	No	No	No
Integrated memory controller	Yes	No	No	No
Front Side Bus Freq	1.6 – 2.6GHz*	800MHz	400MHz	2 x 667MHz
Front Side Bus BW	12.8 – 20.8GB/s*	6.4GB/s	3.2GB/s	2 x 5.3GB/s
Max Inter-Processor BW	8.0GB/s	6.4GB/s	3.2GB/s	5.3GB/s
Memory Support	DDR-266/333/400	DDR-333 / DDR2-400	DDR-200	DDR-333 / DDR2-400
Memory BW 2P System	12.8GB/s **	6.4GB/s	6.4GB/s	12.8GB/s
Memory BW 4P System	25.6GB/s **	N/A	6.4GB/s	12.8GB/s
L2 Cache Size	1MB per core	1 or 2MB	512KB	1MB
L3 Cache Size	N/A	N/A	4MB	0MB, 4MB or 8MB
Max I/O BW 2P System	12.8GB/s	12.3GB/s	4.8GB/s	14.0GB/s
Max I/O BW 4P System	25.6GB/s	N/A	4.8GB/s	14.0GB/s

* Front Side Bus runs at processor frequency

** Assumes DDR-400



Shared Bandwidth

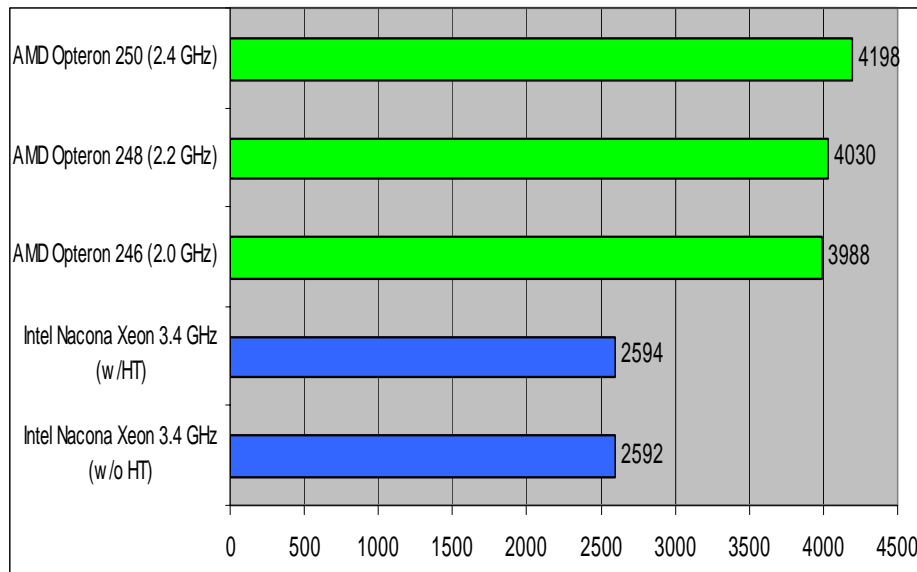
Memory Benchmarks

Embedded Controller Advantage



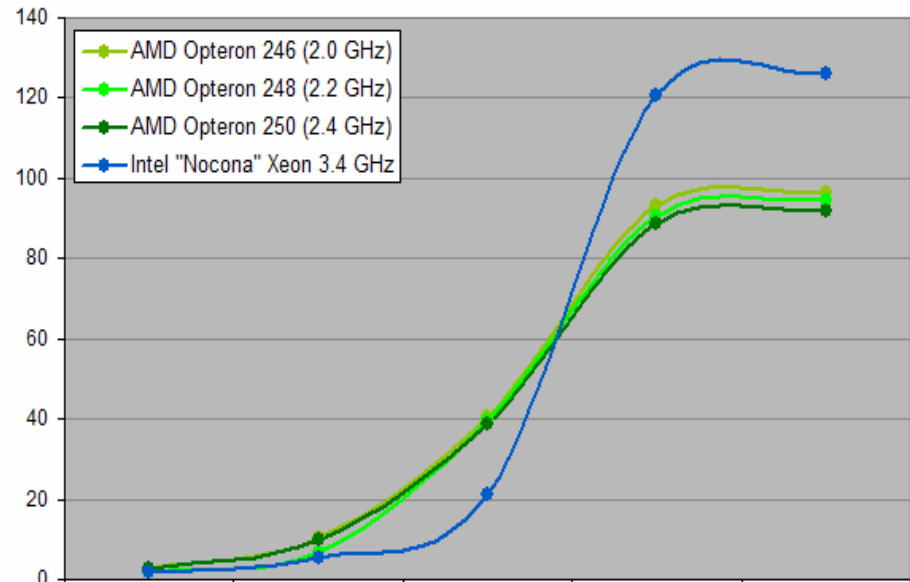
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Opteron has 62% More Bandwidth



SiSoft Sandra 2004 is a synthetic test for stressing individual components. The tests can stress a system's CPU, Memory, or Multimedia capabilities. Higher Sandra scores mean better overall component performance.

Opteron has 22% Lower Latency



Sciencemark is a synthetic benchmark which stresses CPU performance. The benchmarks are a collection of science and physics mathematical calculations. Tests use default Molecular Dynamics and Primordia benchmarks. Lower times mean better performance.

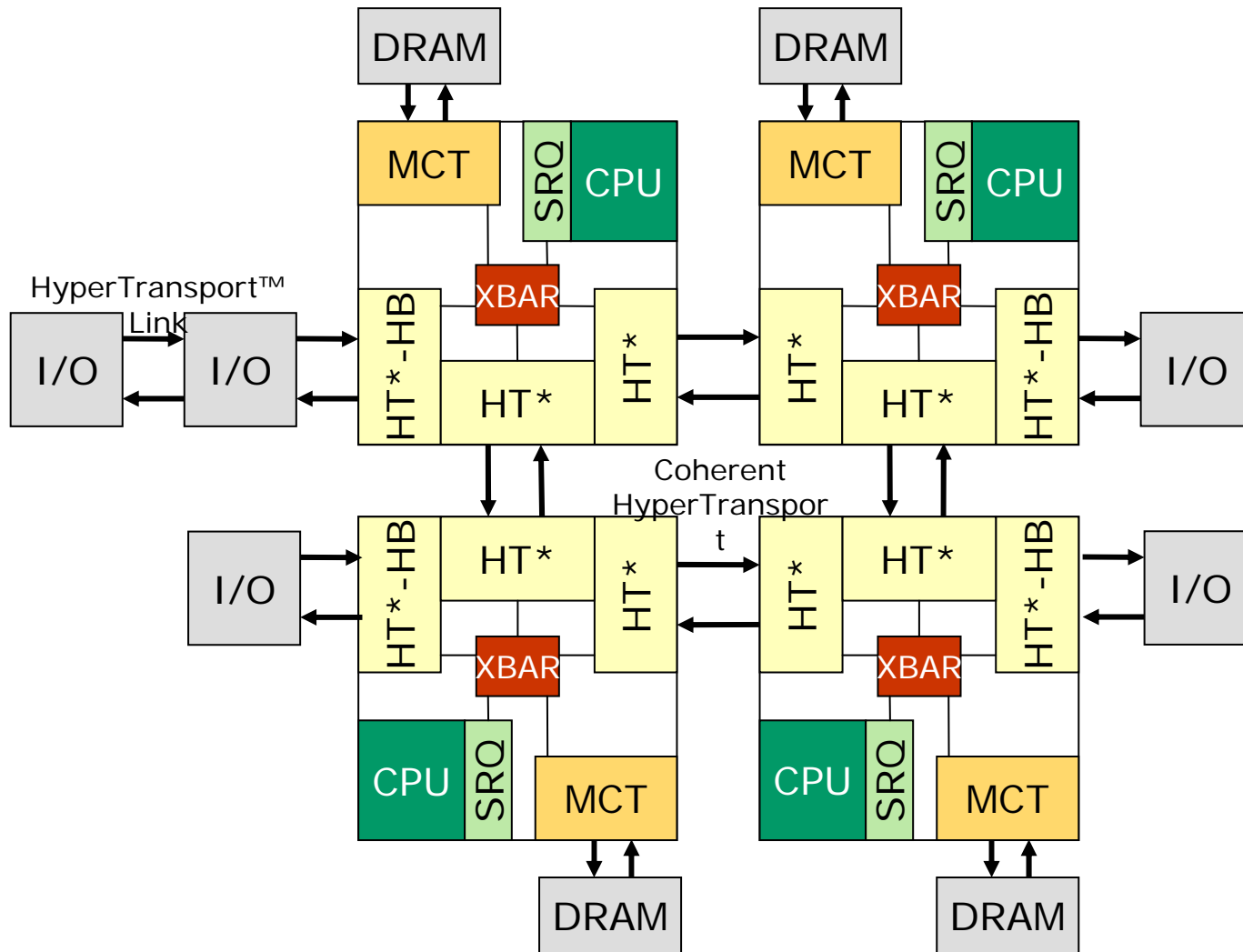
"The memory latency numbers aren't incredibly surprising though, as the Opteron has an inherent memory latency advantage, as the processor holds the memory controller directly on the processor die. The Xeon processor must shuffle data through the E7525 MCH, which puts its memory latency numbers at around 120ns at its peak, while the Opterons hover around 80ns. We noticed that our memory latencies measured higher when each Opteron CPU has to address its own dual channel DDR-400 banks. On single CPU Opteron and Athlon64 systems, memory latencies would be down in the 40ns range."

Opteron Architecture

HyperTransport™ Layout



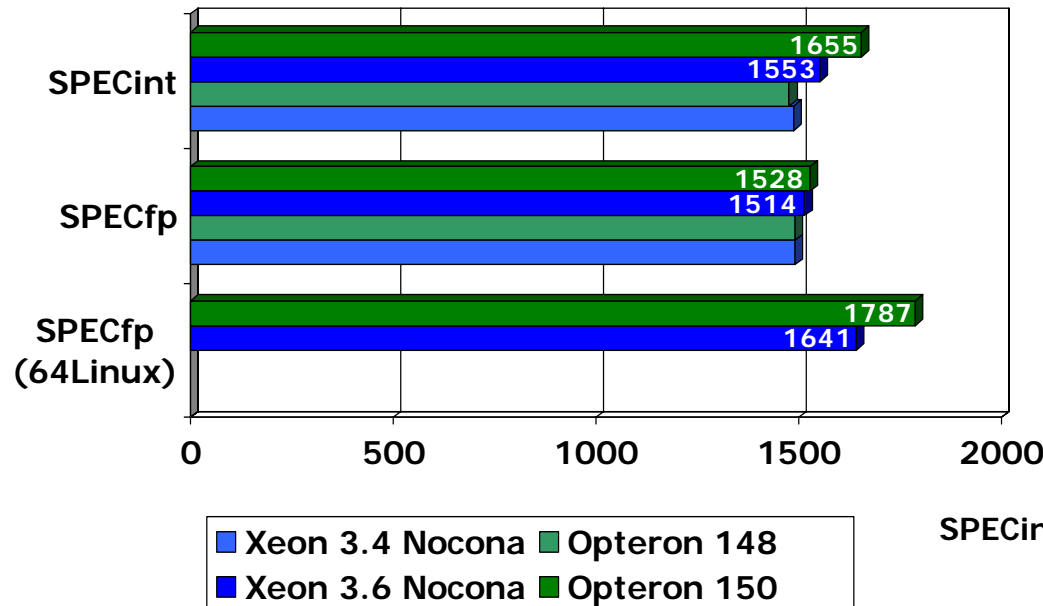
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Benchmarks, 1->2 CPU Scaling It's the System!!

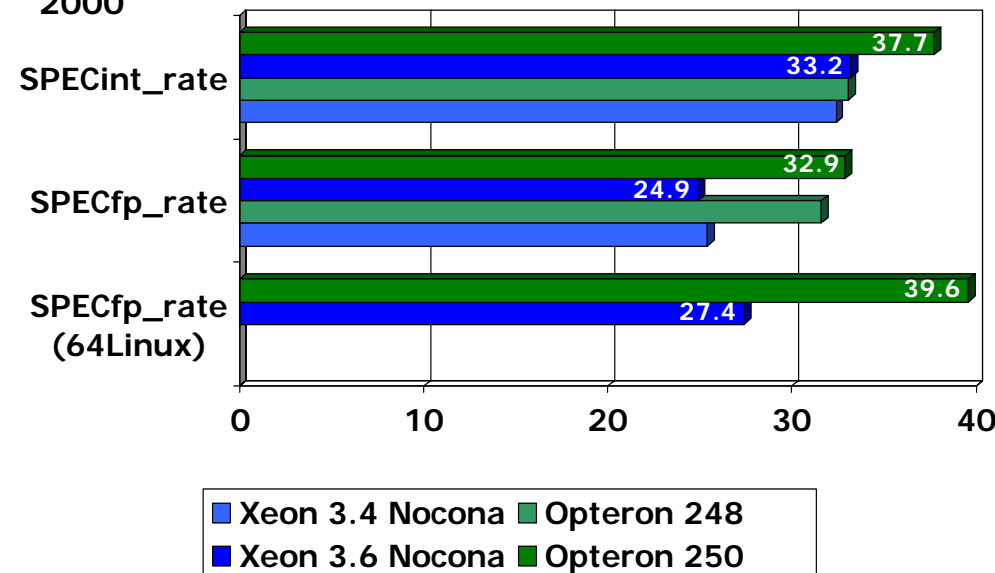


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Opteron Advantage		
	1 CPU	2 CPU
SPECint	7%	14%
SPECfp	1%	32%
SPECfp-64	9%	45%

November 1, 2004 www.spec.org



It's not CPU Frequency!

Example: SPECfp_rate w/64bit Linux

Opteron 150 CPU Freq = 2.4GHz

Intel Nacona 3.6 CPU Freq = 3.6Ghz

Nacona CPU Freq 50% faster, but....

Opteron system 45% faster....

It's the components and the design.....

CPU, Memory Controller, & Hypertransport

Top 4-way x86 SPECint_RATE (4P) (peak scores)



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76.7 → Sun V40z w/ 4 x 2.6GHz Opteron 852

72.2 → Dell PE6850 w/ 4 x 3.33GHz Xeon MP w/ 8M

67.5 → IBM x366 x/ 4 x 3.66GHz Xeon MP

63.5 → Sun V40z w/ 4 x 2.4GHz Opteron 850

56.4 → Dell PE6850 w/ 4 x 3.66GHz Xeon MP

www.spec.org – as of July 7, 2005

6% more than Dell “Potomac” 4-way

36% more than Dell “Cranford” 4-way

Top 4-way x86 SPECfp_RATE (4P) (peak scores)



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87.1 → Sun V40z w/ 4 x 2.6GHz Opteron 852

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52.5 → Dell PE6850 w/ 4 x 3.33GHz Xeon MP w/ 8M

34.4 → Dell PE6850 w/ 4 x 3.66GHz Xeon MP

www.spec.org – as of July 7, 2005

66% more than Dell “Potomac” 4-way








153% more than Dell “Cranford” 4-way

AMD Opteron™ Power Advantage

CPU level Published Specs: Max Power



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	AMD Opteron Processor			Xeon			Itanium 2
	EE	HE	Standard	LV	'Nocona'	'Irwindale'	
CPU Max Wattage	30W	55W	95W	55W	111W	120W	130W
2P Server Wattage							
CPU Wattage (2 Processors)	60W	110W	190W	110W	222W	240W	260W
Memory Controller (MC) Wattage	0W (integrated)	0W (integrated)	0W (integrated)	22W	22W	22W	22W
Total CPU+MC Wattage	60W	110W	190W	132W	244W	262W	282W
CPU+MC Cost (Per Node/Year)							
Power	\$ 53	\$ 96	\$ 166	\$ 116	\$ 214	\$ 230	\$ 247
Cooling	\$ 26	\$ 48	\$ 83	\$ 58	\$ 107	\$ 115	\$ 124
Total CPU+MC Cost per Node	\$ 79	\$ 145	\$ 250	\$ 173	\$ 321	\$ 344	\$ 371
500 Node Cost (Annual)	\$ 39,420	\$ 72,270	\$ 124,830	\$ 86,724	\$ 160,308	\$ 172,134	\$ 185,274
Energy Cost Differential	Save 68% \$85,410	Save 42% \$52,560	BASELINE	Save 31% -\$38,106	28% More +\$35,478	38% More +\$47,304	48% More +\$60,444
Energy Cost Differential	Save 45% \$32,850	BASELINE	73% More +\$52,560	20% More +\$14,454	122% More +\$88,038	138% More +\$99,864	156% More +\$133,004
Energy Cost Differential	BASELINE	83% More +\$32,850	217% More +\$85,410	120% More +\$85,410	307% More +\$120,888	337% More +\$132,714	370% More +\$145,854

\$.10 Kilowatt/hour used in determining the power cost (California rate)

\$.05 Kilowatt/hour used in determining the cooling cost (rate will vary by user)




Energy includes power input & cooling, Power Utility cost: \$0.10/KW-hr, Publicly available processor & chipset specifications. The examples contained herein are intended for informational purposes only. Other factors will affect real-world power consumption and cost.

AMD Opteron™ Power Advantage

CPU level / Published Specifications (2-way)



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	Opteron 2xx	"Nacona"	"Irwindale"
CPU	95 watts	111 watts	120 watts
Memory Controller	0 watts (integrated)	22 watts	22 watts
Power SubTot (2-way)	190 watts	244 watts	262 watts
1x2P/year	\$249.66	\$320.62	\$344.27
500 2P Annual	\$124,833	\$160,308	\$172,134
Energy Cost Differential	BASELINE	28% More	38% More




Energy includes power input & cooling, Power Utility cost: \$0.10/KW-hr, Publicly available processor & chipset specifications;
(Assumes 50% additional power usage for HVAC/cooling)

AMD Opteron™ Power Advantage

CPU level / Published Specifications (4-way)



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	Opteron 8xx	"Cranford"	"Potomac"
CPU	95 watts	120 watts	136 watts
Memory Controller	0 watts (integrated)	58.5 watts	58.5 watts
Power SubTot (4-way)	380 watts	538.5 watts	602.5 watts
1x4P/year	\$499.32	\$707.59	\$791.69
Energy Cost Differential	BASELINE	41.7% More	58.5% More

Energy includes power input & cooling, Power Utility cost: \$0.10/KW-hr, Publicly available processor & chipset specifications;
(Assumes 50% additional power usage for HVAC/cooling)

AMD 90nm SOI Technology Leadership **AMD**

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Total System Power Consumption - Idle

(Lower power consumption numbers are better.)



When the processors are sitting idle, power consumption levels are fairly close between Intel's Xeon / 2MB processors and AMD's 0.13 micron Opteron 250 and 248 processors. The big story here is the Opteron 252 processor, which consumes far less power than we anticipated; 50W less than the (lower-clocked) Opteron 250. AMD's 90nm technology is paying off in a big way here.

http://www.gamepc.com/labs/view_content.asp?id=x36o252&page=4

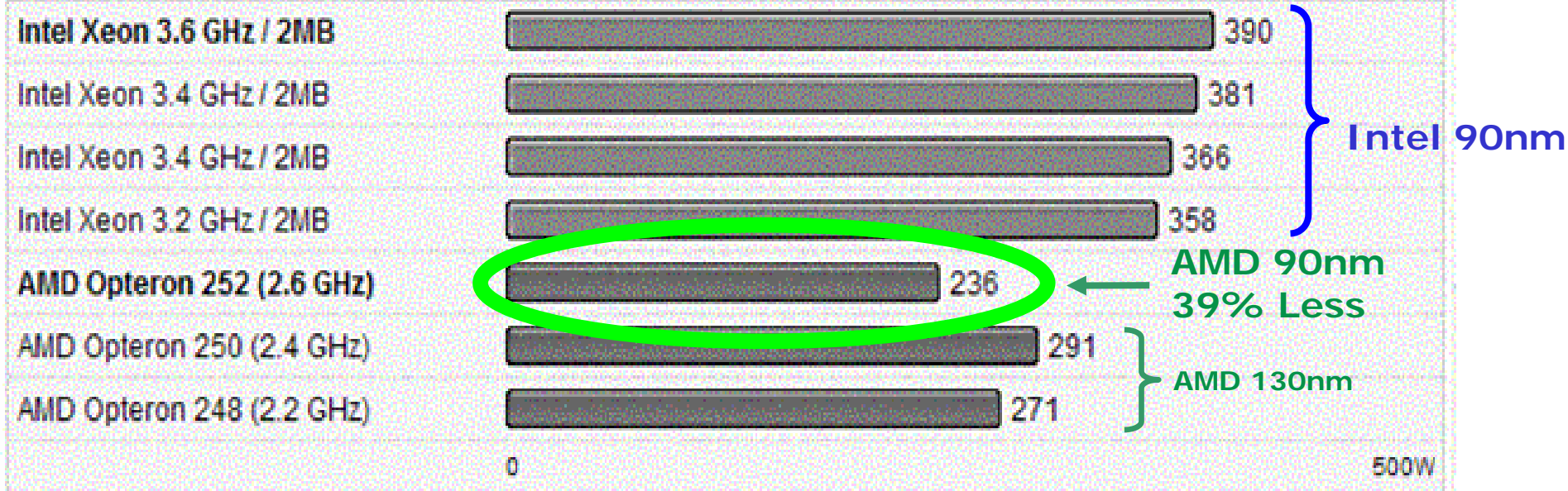
AMD 90nm SOI Technology Leadership

39% System Power Savings

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Total System Power Consumption - Full Load

(Lower power consumption numbers are better.)



When the systems are put under full load, Intel's Xeon / 2MB processors consume quite a bit more power compared to Opteron, roughly 80-90W more. Opteron 252 processors continue to run on amazingly low amounts of power, consuming only 236W for a full dual Opteron 252 system with a GeForce 6800 Ultra PCIe graphics card – very impressive! Dual Xeon 3.6 GHz / 2MB chips consume 150W+ more power compared to dual Opteron 252, making the Opteron 252 a much better choice for power / heat conscious environments like rackmounts and data centers.

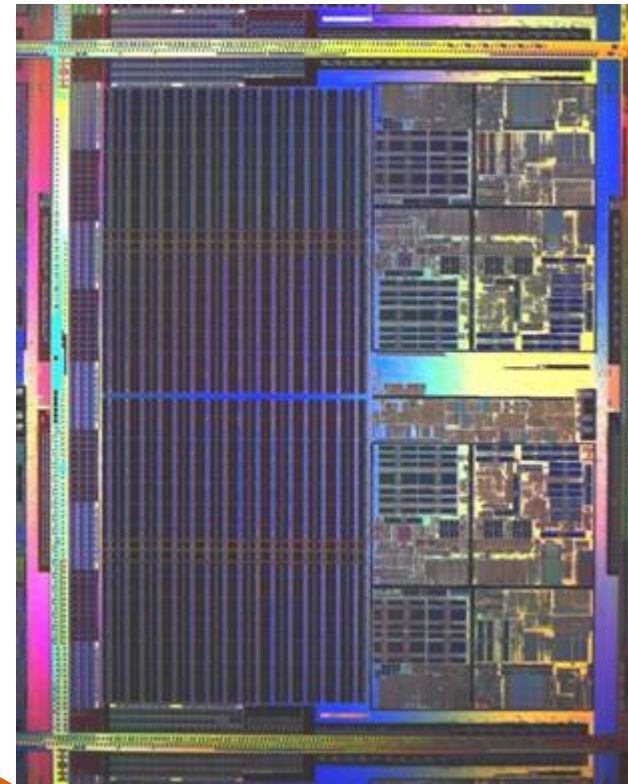
http://www.gamepc.com/labs/view_content.asp?id=x36o252&page=4

Another AMD First



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- First discussed publicly in 1999, AMD64 was designed from the ground up to be optimized for multiple cores
- AMD is the first in the industry to demonstrate an x86 dual core processor
- Demonstrated a 4-socket server powered by four dual core AMD Opteron processors
- Evolutionary Direct Connect Architecture connects two cores on the same die
- Providing our partners a competitive advantage in the market
- **Dual core AMD Opteron™ processors for servers and workstations launched April 21st, 2005**



Photograph of 90nm dual-core AMD Opteron™ processor prototype

- **Ease of Migration to Dual Core Processors**

- HP, IBM and Sun and other system manufacturers will be able to easily incorporate dual core products into their existing AMD Opteron™ processor-based designs
- End users can upgrade their existing systems that are compatible with 90nm single core processors to dual core processors

- **Higher Performance Per Watt**

- Customers will experience the performance advantages of dual core processors by getting the best performance per watt available in the market

- **Direct Connect Architecture**

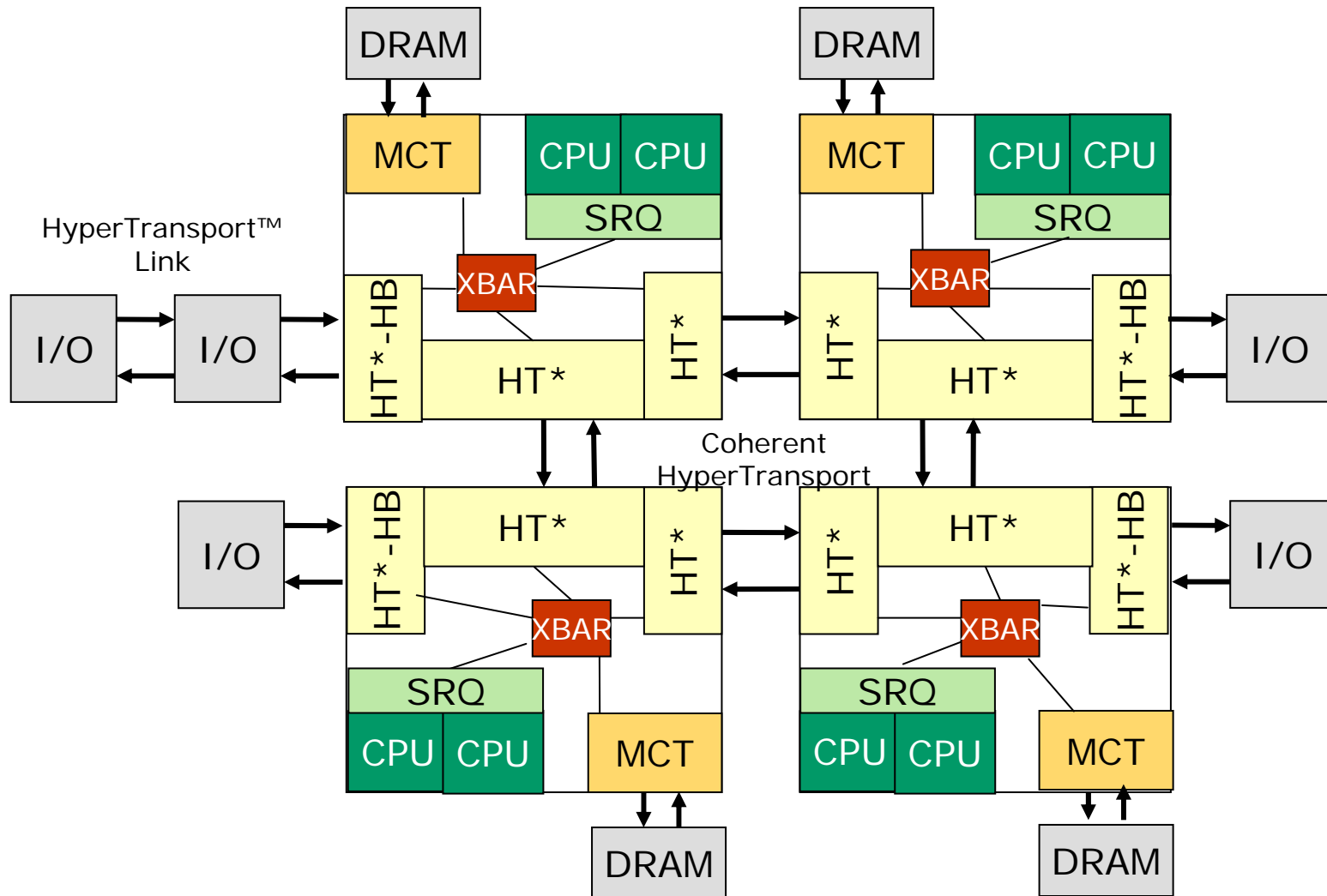
- Best 2 processor and 4 processor architecture for x86 computing
- Addresses and helps eliminate the real challenges and bottlenecks of system architecture because everything is directly connected to the CPU
- Directly connects the two processor cores on to a single die for even greater reduced latencies between processors

Opteron Architecture

HyperTransport™ Layout



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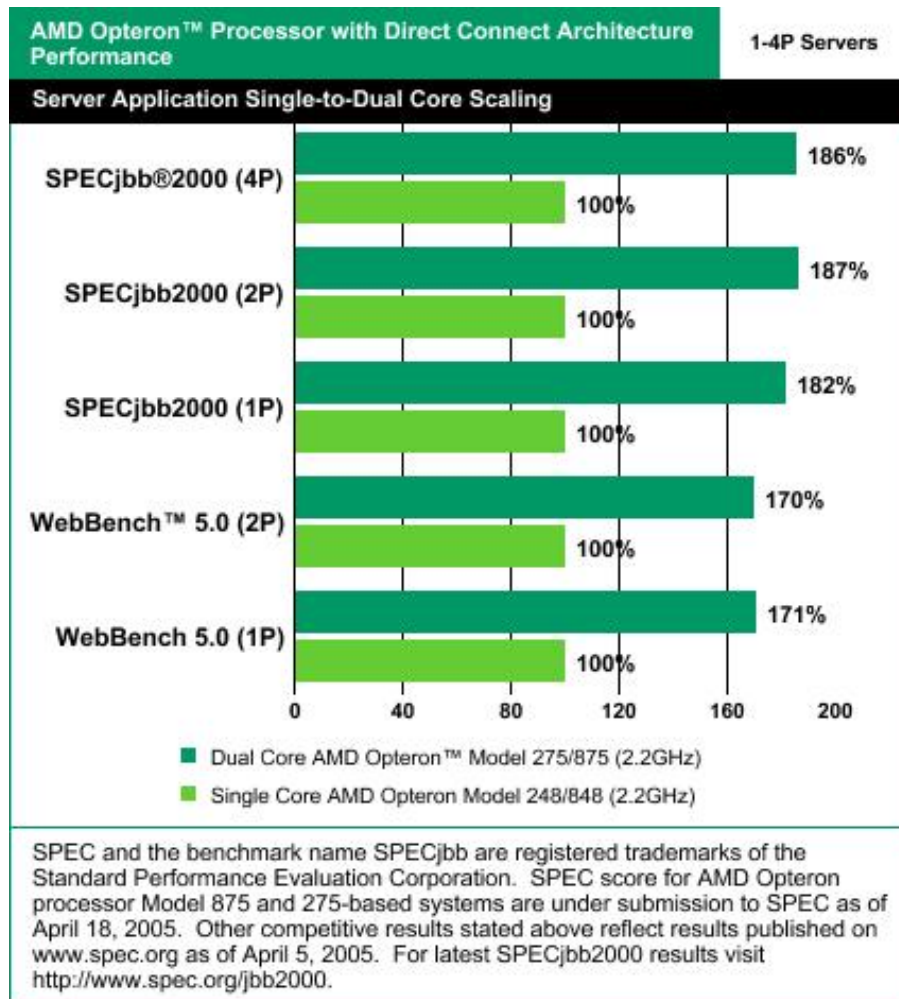
Dual-Core AMD Opteron™ Processor Performance

1-4P Server Application Single-to-Dual Core Performance

SPECjbb®2000 and WebBench™ 5.0 (Windows®)



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Comparison of same frequency dual core (875 and 275) and single core (848 and 248) AMD Opteron™ processors

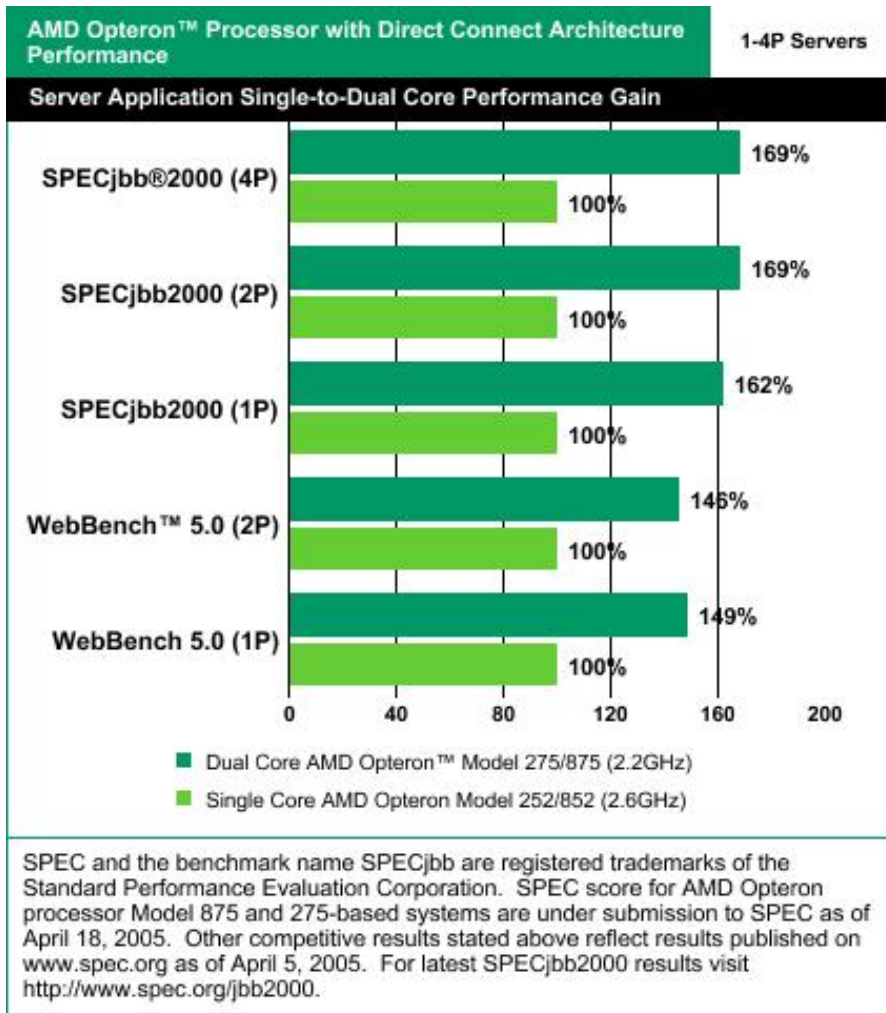
Dual-Core AMD Opteron™ Processor Performance

1-4P Server Application Single-to-Dual Core Performance

SPECjbb®2000 and WebBench™ 5.0 (Windows®)



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Comparison of highest performing dual core (875 and 275) and single core (852 and 252) AMD Opteron™ processors

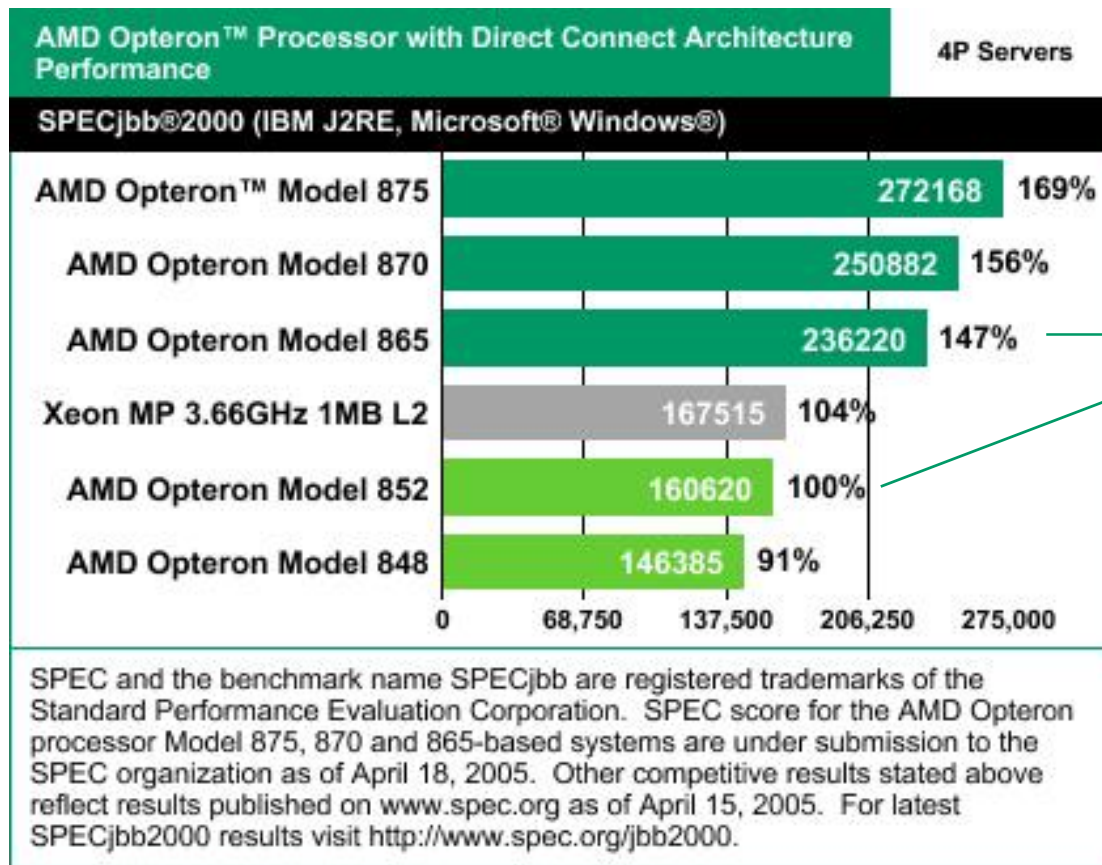
Dual-Core AMD Opteron™ Processor Performance

4P Java Application Server Performance

SPECjbb®2000 (IBM JVM, Windows®)



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Dual and single core AMD Opteron™ processors that are offered the same price - lowest performing dual core (865) and highest performing single core

SAP S&D 2-Tier Benchmark (Windows) 2-way

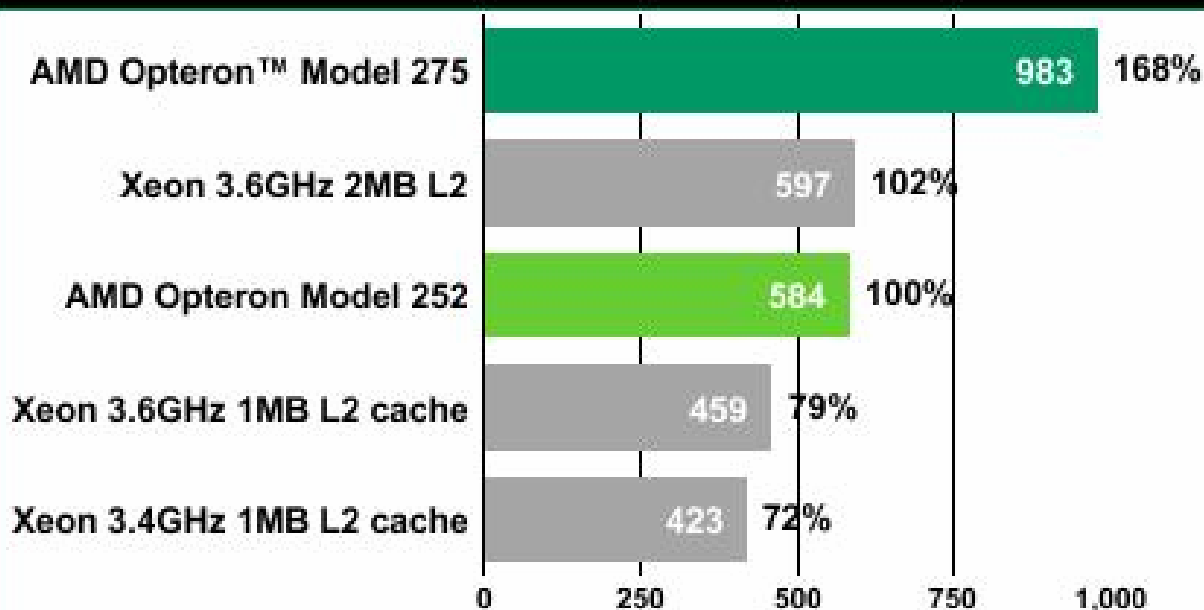


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AMD Opteron™ Processor with Direct Connect Architecture Performance

2P Servers

SAP® Standard Application Sales and Distribution (SD) 2-Tier Performance
Microsoft® Windows® Server 2003 with Microsoft SQL Server 2000



SAP is a registered trademark of the SAP Corporation. Microsoft and Windows are registered trademarks of the Microsoft Corporation in the United States and other jurisdictions. For complete SAP benchmark information visit <http://www50.sap.com/benchmarkdata/sd2tier.asp>.

SAP S&D 2-Tier Benchmark (Windows) 4-way

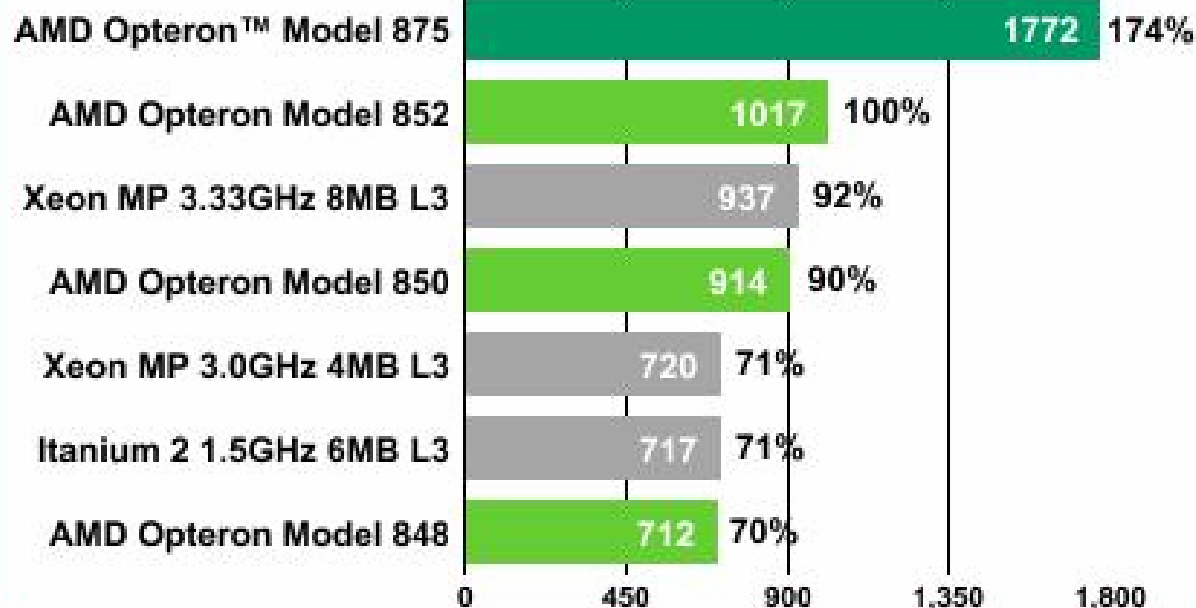


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**AMD Opteron™ Processor with Direct Connect Architecture
Performance**

4P Servers

**SAP Standard Application Sales and Distribution (SD) 2-Tier Performance
Microsoft® Windows® Server 2003 Enterprise Edition**

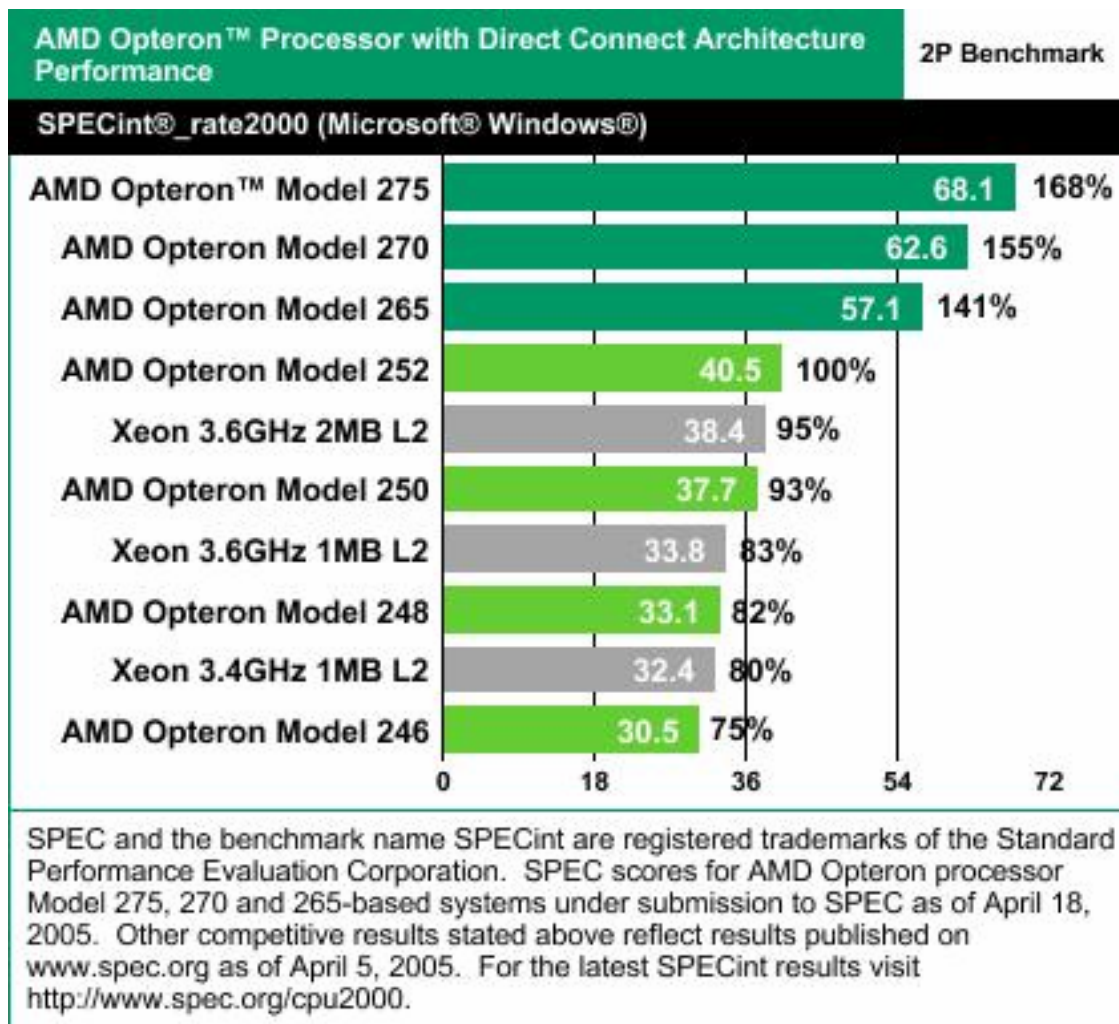


Microsoft and Windows are registered trademarks of the Microsoft Corporation in the United States and other jurisdictions. For complete SAP benchmark information visit <http://www.sap.com/benchmark>.

SPECint_rate2000 (peak) 2-way



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Top 4-way x86 SPECint_RATE (4P) (peak scores)



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111 → Sun V40z w/ 4 x 2.2GHz Opteron 875 (dual core)

76.7 → Sun V40z w/ 4 x 2.6GHz Opteron 852

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53% more than Dell "Potomac" 4-way

97% more than Dell "Cranford" 4-way

www.spec.org – as of July 7, 2005

Top 4-way x86 SPECfp_RATE (4P) (peak scores)



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138 → Sun V40z w/ 4 x 2.2GHz Opteron 875 (dual core)

87.1 → Sun V40z w/ 4 x 2.6GHz Opteron 852

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52.5 → Dell PE6850 w/ 4 x 3.33GHz Xeon MP w/ 8M

34.4 → Dell PE6850 w/ 4 x 3.66GHz Xeon MP

www.spec.org – as of July 7, 2005

163% more than Dell “Potomac” 4-way

301% more than Dell “Cranford” 4-way

Building the AMD64 Ecosystem



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The AMD64 Software Ecosystem Continues to Grow!

- Thousands of x86-based applications run today on AMD64 processors
- Over 300 ISVs and open source software organizations are actively promoting AMD64 compatibility
- AMD64 processors are driving major O/S ecosystems
 - Microsoft, Sun, Novell, Red Hat
- AMD64 technology is becoming a key component in software roadmaps
 - Windows® "Longhorn"
 - Virtualization software
- Access the AMD64 Ecosystem online to find the most up-to-date listing of 32- & 64-bit software that support AMD64 technology at

www.amd.com/amd64ecosystem

AMD64 Ecosystem Web Site Apr. 2005 Statistics

Over 300 Development Organizations

Over 1,300 packages certified for AMD64
over 1,150 are shipping

120 operating system (versions)
Includes Linux, Solaris, UNIX, Windows®
52 are 64-bit (32 shipping)

307 Development Tools (versions)
115 are 64-bit (87 shipping)

52 Database Engines (versions)
19 are 64-bit (13 shipping)

385 Infrastructure Applications
101 are 64-bit (76 shipping)

470 Vertical Applications
171 are 64-bit (114 shipping)

Dual Core AMD Opteron™ Processor

Operating Systems Optimized for Dual Core



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OS Launch Partners	OS Versions Optimized for Dual Core	Status
Mandriva		Released
Microsoft	Windows Server 2003 SP1 Windows Server 2003 x64 Windows XP Pro SP2 Windows XP Pro x64	Released Released Released Released
Novell	Novell SUSE Linux 9.3 Novell SLES 9 SP1 Maintenance	Gold Master Released
Red Hat	RHEL 3.0 U5 RHEL 4.0 U1	Beta Beta
Sun	Solaris 10	Released

- A complete listing of operating system versions that support AMD64 technology is available on the AMD64 Software Ecosystem web site:
<http://www.amd.com/amd64ecosystem>
- Please contact the OS vendor directly for more detailed information on dual core optimizations.

Dual Core AMD Opteron™ Processor

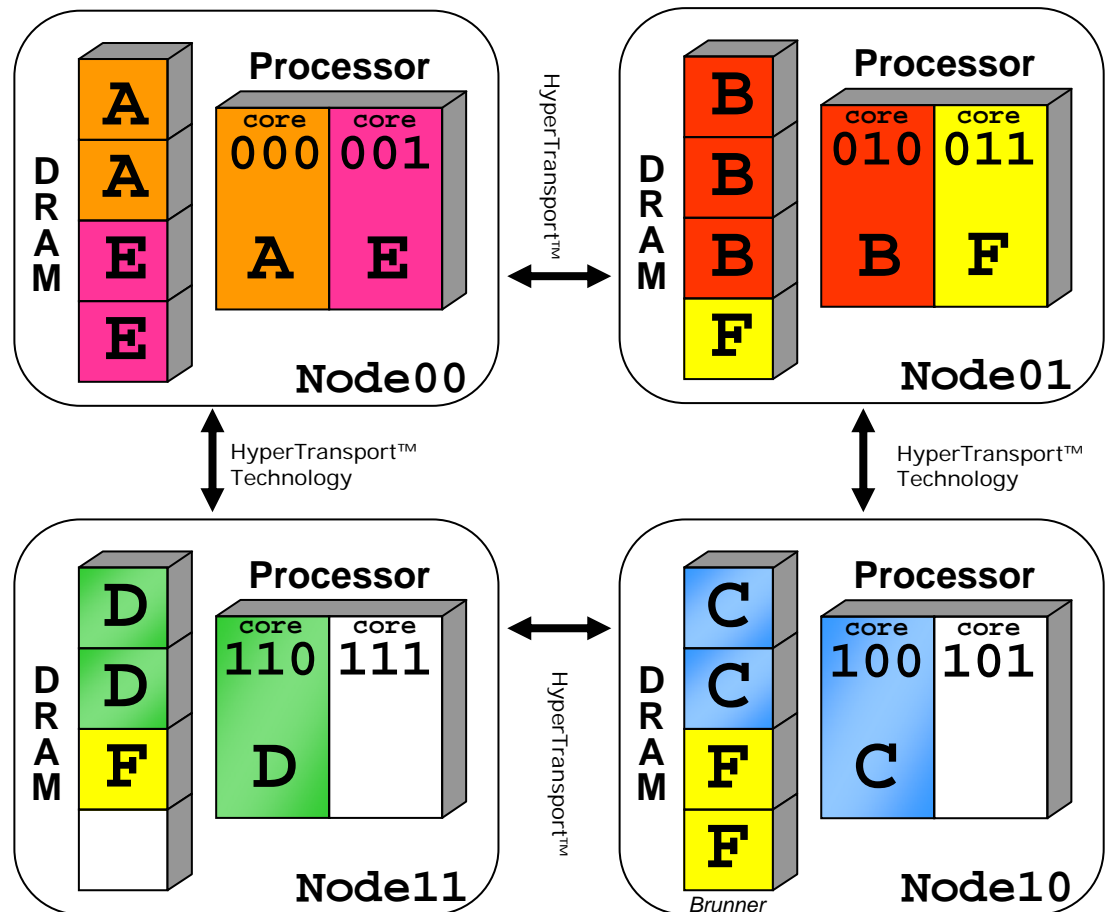
Operating System Scheduling Example



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Example of an OS optimized for dual core running on an AMD Opteron™ processor-based system with 4 dual core processors

- OS distributes threads across processors *first* to minimize contention between threads
- OS attempts to map a thread's memory requests to the local memory of the node (Threads A, B, C, D, E)
- If no memory is left on the current node, OS will use memory of other nodes (Thread F)



Run in slide show mode to view animation of OS scheduling for dual core

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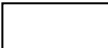
THANK YOU


AMD Opteron Processor Comparisons



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	Opteron 200 Series (for 2P Systems)	Opteron 800 Series (for 4P or 8P Systems)
1.8 GHz	244	844
2.0 GHz	246	846
2.2 GHz	248	848
2.4 GHz	250	850
2.6 GHz	252	852
1.8GHz *	265	865
2.0GHz *	270	870
2.2GHz *	275	875

 130 nm / 89W dissipation

 90 nm / 95W dissipation

* Dual Core Opteron Processors